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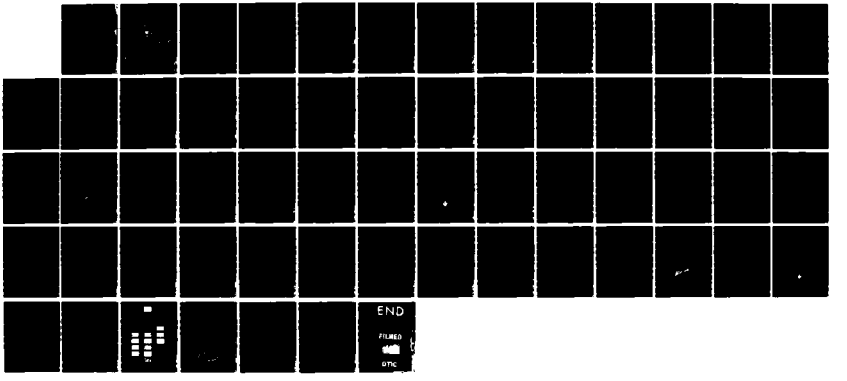

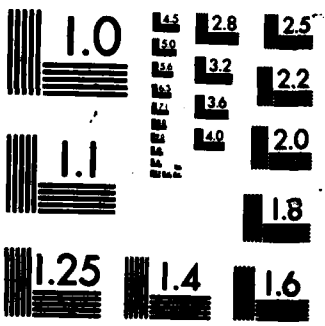

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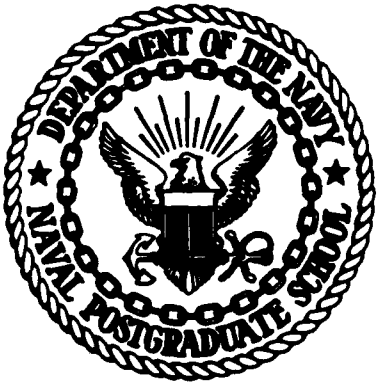

THESIS

OZDRAW: A REAL-TIME INTERACTIVE FIGURE GENERATION SYSTEM

by

Steven J. Firth

December 1985

Thesis Advisor: Michael J. Zyda

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This study examines the usual approaches used by individuals and organizations to produce technical illustrations. These approaches can be categorized into three major areas, the traditional approach, semi-automatic method and fully-automatic methods. Each approach is described and its advantages and disadvantages discussed. Finally OZDRAW, a fully-automatic figure generator system, developed as part of this study, is described.

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OZDRAW: A Real–Time Interactive Figure Generation System

by

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requirements for the degree of

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ABSTRACT

This study examines the usual approaches used by individuals and organisations to produce technical illustrations. These approaches can be categorised into three major areas; the traditional approach, semi-automatic methods and fully-automatic methods. Each approach is described and it's advantages and disadvantages discussed. Finally OZDRAW, a fully-automatic figure generation system, developed as part of this study, is described.

TABLE OF CONTENTS

I. INTRODUCTION

The capability to produce and reproduce quality technical figures, such as those found in official reports and academic papers is invaluable in a business, administrative or academic environment. Ideally, the user should have the ability to produce a figure quickly and with a minimum of effort. Further, if the user is using an automated or semi-automated process he should not be encumbered by the requirement to learn, and hence remember, complex operating procedures; the system should be simple, self-documenting, powerful and yet be able to be used by an untrained person.

Numerous automated systems have been devised to aid the author in the figure generation process. Few of these systems have used visual feedback during figure production. These non-visual systems tend to be based upon operating system-like command interfaces. The main reason for this limitation was the prohibitive expense of computer-graphics terminals and workstations with sufficient capabilities to provide real-time, interactive feedback. With the advances in display technology has come a significant drop in price such that this has become less of a problem. Consequently, this ~~study~~ thesis re-opens the issue of computer-assisted technical figure generation. It does this in terms of a real-time, interactive figure generation system called OZDRAW. Keywords: technical illustrations; user manuals.

II. REQUIREMENTS OF A TECHNICAL DRAWING SYSTEM

A. BACKGROUND

The requirements of the technical illustrator are very much different than that of an artist. This is true not only from the aspect of the finished product but also from the way the two different individuals construct the product. Thus the figure generation process has distinct characteristics. A useful figure generation system must incorporate these characteristics into the system.

B. DESIRABLE SYSTEM CHARACTERISTICS

1. System Must be Quick and Efficient

Production of a technical drawing is heavily goal-orientated; that is the author is more interested in the finished product than he is in the generation process. For the artist however, the process of creating his art can be as important, or even more important, than the finished art-work. Therefore, a technical figure generator must be able to produce drawings quickly and efficiently or the system will not be used.

2. System Must be Intuitive

The system must have a natural intuitive approach to figure generation. The importance of this cannot be underestimated; no matter how efficient the system is at producing figures, if the user feels uncomfortable in the figure production he will go elsewhere.

3. Low Set-up Costs

The ideal system would have small initial set-up costs; this would either enable initial expenditures to be reduced or that more systems could be purchased for a reasonable amount of money.

4. System Must Be Cheap to Use

A figure generation system must be cheaper, in either time or money or both, than an existing method of producing technical figures; if not, the system will fall into disuse.

5. System Must Be Convenient

The system must offer the user greater convenience than he is currently offered. Human beings tend to ignore systems that may be of great advantage to them simply because they are slightly inconvenient to use.

6. System Must Accommodate Unskilled Users

The technical illustrator generally will have little technical drawing expertise. This is understandable as the author who requires the technical drawing is usually not skilled in this field and is only using the system as a tool. Conversely, the artist may take many years acquiring expertise to achieve his level of artistic excellence. Therefore a figure generation system must be able to be used by the untrained, inexperienced and even disinterested.

7. System Must Produce a High Quality Product

The artist's work generally can be classed as esoteric and thus its quality cannot be quantified. As many contemporary art-works have shown art can use any medium to express itself. The technical drawing on the other hand does not have this latitude. The printed paper must be of good quality and the drawn figures produced must be crisp, clear and well-defined. Therefore the figure generation system must be capable of outputting to a quality graphic printer, ideally a laser printer or to a good quality plotter. The laser printer is the preferred output device.

8. Ease of Modification

Technical figures are subject to frequent change for many reasons. Technical aspects of the drawing may have changed or even proven incorrect. Even the humble page number alteration may require complete redrawing to maintain the original quality. Artistic works are not subject to frequent change.

Therefore a figure generation system must be capable of modifying the drawing at any time after the original drawing process.

9. Ease of Reproduction

Technical figures may need to be reproduced many times, depending on the requirements. Artistic works usually do not need to be reproduced with the original quality. Hence a figure generation system must be able to store and hence reproduce drawings.

10. Basic Geometric Figures Supported

The technical figure illustrator requires a different domain of geometric shapes than that of the artist. The technical illustrator requires clearly defined regular shapes while the artist requires quite the opposite. Therefore, the majority of technical figures can be generated from a relatively few primitive geometric shapes. The most common shapes required of a technical drawing are:

- the polygon, which includes squares and rectangles;
- the circle,
- the ellipse,
- arcs,
- text,
- lines, and
- arrows.

Technical drawings require different attributes for drawing figures. The following attributes are commonly required:

- texture,
- fonts,
- line-style, and
- line-width.

TABLE 2.1 - SUMMARY DESIRABLE SYSTEM CHARACTERISTICS
Quick and Efficient
Must Be Intuitive
Low Set-up costs
Cheap to Use
Must Be Convenient
Accommodate Unskilled Users
Produce a Quality Drawing
Easy to Modify Figures
Easy to Reproduce Figures
Supports Basic Geometric Shapes

III. TRADITIONAL APPROACHES

Two approaches to figure generation will be identified as *traditional* and examined below. They are :

- the author produces his own figures, and
- a draftsman is employed to produce the final version.

A. AUTHOR PRODUCES OWN FIGURES

This method is probably the most common method to produce figures, both in the business and academic environments. The author is responsible for the entire production of the figures.

1. Advantages

The two main advantages to this method is that it is very convenient and no significant cost is involved in setting up the system. This system is completely convenient to the author; figures can be produced at any reasonable time and place. The author is not constrained by being forced to compete for resources, such as draftsmen or computer facilities. As well, no large investments for drawing facilities need be made. Probably the only material requirements are a technical drawing set and drawing board. The more automated systems described later may require large investments in computer hardware and printers; many small organisations cannot afford these.

This approach can accommodate the unskilled author. This method of drawing is very intuitive. However, the time involved and quality of the figures produced may be far from ideal.

2. Disadvantages

This approach in general is neither quick nor efficient. The average illustrator will probably not be experienced in technical figure generation. It can be anticipated that lengthy periods will be required for figure production. Even

though this does not involve any direct costs, indirect costs for the author being distracted from his proper employment can be great.

Figure quality is totally dependent on the ability of the unskilled illustrator. Not surprisingly, it has been observed that the quality of figures produced can vary considerably. These high drawing costs are unfortunately not *once-only* costs. If the drawing needs to be reproduced there are two alternatives; either photo-copy the drawing with its unavoidable reduction in quality or to redraw the entire drawing. If copying the drawing is unacceptable, the redrawing will cost approximately the same time and money the *nth* time it is redrawn as it did the first time. This is certainly true if the drawing has to be modified in some way; redrawing is the only alternative.

TABLE 3.1 - SUMMARY USER PRODUCES OWN FIGURES	
Characteristic	
Quick and Efficient	No
Intuitive	Yes
Low set-up costs	*Negligible*
Cheap to Operate	No direct overhead
Convenient	Very
Accommodate Unskilled Users	Yes
Quality Product	User dependent - quality not guaranteed
Ease of Reproduction	Complete redraw required
Ease of Modification	Complete redraw required
Geometric Shapes	No

B. DRAFTSMAN PRODUCES FIGURES

The other most common approach to figure generation is for the organisation to employ a draftsman. Using this method, the author roughly draws the diagram as he requires it and then hands it to the draftsman for completion. This has been the traditional approach of the larger organisations and institutions.

1. Advantages

This approach is an extension of the above approach; for the author it is still a convenient, intuitive way to draw figures and as the draftsman completes the figures the drawing skill of the author does not generally impinge on the process. Since figure production is the draftsman's profession, a quality product is generally produced. Set-up costs will be generally more expensive than the above approach but can still be considered negligible.

In addition, draftsman can reproduce figures in quantity both quickly and cheaply given the requirements in advance. However after the initial production, additional significant expense is generally incurred for additional copies.

2. Disadvantages

For the larger organisation, this approach is usually more cost effective than having the author produce his own figures; however it is still costly and inefficient. Employing draftsman adds an extra employee to the organisation with the associated added expense. In a large organisation this draftsman is utilized by many employees; significant time delays can develop if the draftsman has a heavy workload.

As before, using a draftsman does not eliminate redrawing costs. Figure modification can be done easily by the author but this still necessitates the redrawing of the figures by the draftsman, with it's associated extra expense.

TABLE 3.2 - SUMMARY DRAFTSMAN PRODUCES FIGURES	
Characteristic	Achievement of Goal
Quick and Efficient	Dependent on organisation
Intuitive	Yes
Set-up costs	Higher than the user approach but still small.
Cheap to Operate	No
Convenient	Yes
Accommodate Unskilled Users	Yes
Quality Product	Usually
Ease of Reproduction	Complete redraw required
Ease of Modification	Complete redraw required
Geometric Shapes	Yes

IV. SEMI-AUTOMATED SYSTEMS

A. BACKGROUND TO SEMI-AUTOMATED SYSTEMS

Various semi-automated systems have been designed and implemented to enable the author to produce technical drawings quickly and easily. (For the purpose of this discussion a "semi-automated" process means an automated system for figure generation that does not use real-time computer graphics in the preparation of the drawing). For instance it is reported that at the Massachusetts Institute of Technology (MIT) a system called DBLOCK is regularly used to produce diagram viewgraphs and text viewgraphs [Ref. 1]. At the Naval Postgraduate School (NPS), the FIG system is used in a more general role as a figure generation system.

B. EVALUATION OF SEMI-AUTOMATED SYSTEMS

1. Advantages

The main advantage that the semi-automated process has to offer is that it enables the draftsman to be eliminated from the customer organisation, thus avoiding the associated costs and time delays. With such systems the author is now in complete charge and is responsible for figure generation from start to finish. This results in quicker turnaround time for figure production.

To compensate for being non-visual, these systems generally have a rich repertoire of geometric shapes from which to choose as part of the command language. This relieves the user of much of the tedium of constructing complex figures without visual feedback.

Figures can be stored and thus can readily reproduced at some later date with insignificant additional cost. Most systems provide mechanisms that allow editing of diagrams so modifications can be carried out and new revised figures redrawn.

2. Disadvantages

As previously stated these systems suffer from being non-visual, thus non-interactive, which renders the system very nonintuitive. To produce a drawing the user has to interact with the system via a command language; the user enters his diagram into the system as a series of primitives, for example BOX with the required page coordinates, attribute commands and general system "house-keeping" commands.

Appendix A details a typical command file from the DBLOCK system and the diagram it produces. Examination of this Appendix will confirm the non-intuitive nature of these systems. Therefore at the very least some user training and experience is necessary before these systems can be used; user acceptance of the system may represent a problem.

As noted above these systems have a rich repertoire of primitive figures from which to choose. This advantage is also a disadvantage as this renders the system user dependent. Most figures that are provided are computer-literature orientated, such as a the "tape- drive" symbol from flow diagrams, and is thus of limited use outside the narrow field of computer related areas.

Set-up costs for this approach can become high. By it's automated nature some computer system is required; a semi-automated system could be implemented on any sized system, from a micro-computer to a mainframe. However, these systems are particularly attractive when there is already a computer system that is used for other purposes and has available time on the system. For instance the FIG system uses a VAX UNIX 11/780 system to produce figures at no additional expense to the Naval Postgraduate School.

TABLE 4.1 - SUMMARY SEMI-AUTOMATED SYSTEM	
Characteristic	**Achievement of Goal**
Quick and Efficient	Better than traditional approaches
Intuitive	No
Set-up costs	Can range from negligible to expensive
Cheap to Use	Yes
Convenient	Generally yes
Accommodate Unskilled Users	Generally some user experience and training is needed
Quality Product	Yes
Ease of Reproduction	Yes
Ease of Modification	Yes
Geometric Shapes	Rich repertoire

V. AUTOMATED FIGURE GENERATION SYSTEMS

A. BACKGROUND

Automated figure generation systems require computer-graphics workstations to give visual feedback in the figure generation process. It is only recently that workstations capable of this have been available relatively inexpensively.

B. EVALUATION OF AUTOMATIC SYSTEMS

At present there are few commercially available automated figure generation systems; the **MACDRAW** programme is an example of such a system. (A description of MACDRAW is given in a later section.) As a result of the relative scarcity of automatic figure generation systems much of the evaluation of these systems is speculative, while some is based on experience gained through development of OZDRAW.

1. Advantages

The primary advantage that automated figure generation systems enjoy is the visual feedback that real-time computer graphics enable. This capability has the potential to greatly increase the speed and efficiency of the drawing process, make the process more intuitive and thus more readily usable by unskilled users. Costs can be controlled as the illustrator is responsible for the entire drawing process; no draftsmen are needed. As with the semi-automatic systems, modification and reproduction of drawings can be done quick and easily.

2. Disadvantages

The two main disadvantages with automatic figure generation systems are:

- high initial set-up costs, and
- specialised hardware is needed, hence available terminals will be limited in numbers.

Small organisations may not be able to afford the initial expense of an automated system. Even modest graphics systems are still more expensive than comparably sized non-graphic systems. Therefore only larger organisations are able to afford dedicated systems. As with semi-automated systems automated systems can take advantage of existing computer-graphics systems that can thus reduce set-up costs to a negligible amount.

Convenience of use of automated systems may be a problem. Automatic systems require specialised hardware, hence the availability of terminals will usually be less than that of a semi-automatic system. If usage is heavy many users may be discouraged from using the system and revert to more traditional approaches.

TABLE 5.1 - SUMMARY AUTOMATED GENERATION SYSTEMS

Characteristic	Achievement of Goal
Quick and Efficient	Yes
Intuitive	For most users yes
Set-up costs	Can range from negligible to expensive
Cheap to Operate	Yes
Convenient	Generally yes
Accommodate Unskilled Users	Yes
Quality Product	Yes
Ease of Reproduction	Yes
Ease of Modification	Yes
Geometric Shapes	Basic set supported

C. THE MACDRAW FIGURE GENERATION SYSTEM

The ***MACDRAW*** programme is an automated figure generation system that was introduced in 1985 [Ref. 2]. This system is designed to run on the ***MACINTOSH*** computer; both are manufactured by APPLE Computer, Inc. of Sunnyvale California. The system uses a laser printer also produced by APPLE.

The complete system can be purchased for less than $10,000. This system is quite affordable; the manufacturer has reduced system cost at the expense of system performance.

MACDRAW is a ***mouse-driven*** system with the user selecting the appropriate function from as series of icons. Basic figures are supported and figure attributes include fonts, line-styles, line-widths and textures.

This system suffers from several limitations. Firstly the screen is monochrome, so no colour differentiation of figures can be employed. The APPLE mouse has only one button, thus restricting the machine to only one function at a time. Continual changing of functions, via the menu, can become time-consuming and frustrating. The menu icons are ambiguous and can confuse the inexperienced user.

VI. THE OZDRAW FIGURE GENERATION SYSTEM

A. BACKGROUND

OZDRAW is a real-time, interactive figure generation system. The system has been designed to run primarily on the ***IRIS 2400*** series of computer-graphics workstations manufactured by Silicon Graphics, Inc. of Mountain View, California. A version is also available for the IRIS ***1400*** workstation. The output of OZDRAW is currently designed for a Quality Micro System (QMS) ***Lasergraphix 1200*** laser printer.

B. AIM OF OZDRAW

The aim of OZDRAW is to produce a powerful, user-friendly figure generation process to enhance the technical figure generation capability of the Computer Science (CS) Department of the US Naval Postgraduate School. Before the introduction of OZDRAW the CS department relied on traditional approaches and FIG, a semi-automated figure generation system implemented on the department's UNIX VAX 11/780 computer system. Both FIG and OZDRAW share a compatible file format so the user is able to produce a figure using either system or a combination of both. The file format is an ASCII file so in fact the user can manipulate the file using a text-editor; this approach is not encouraged but is an option for the experienced user.

C. DESCRIPTION OF SYSTEM

OZDRAW exploits the high-performance graphics capabilities of the IRIS workstation in the figure-generation process. This performance capability has allowed the development of a *mouse-driven system* that uses *pop-up menus* to provide a friendly interface between user and system. All commands to the system are via menus; the user scrolls up or down the appropriate menu using two of the mouse buttons, and then selects the required command by the third button. As text is used to describe menu choices rather than icons, the user is not

confronted with confusing or contradictory choices. This approach is well suited to the inexperienced user and also the user who uses the system infrequently.

The system supports the following geometric shapes:

- rectangles and polygons,
- circles and ellipses,
- single and multiple lines,
- arcs,
- a seed point to fill unconventional figures,
- text, and
- attributes of texture, line-width, line-style and font.

Certainly other more complex drawing primitives can be identified and it may be argued by particular users that OZDRAW's choice is too limited. The reason support has been restricted to these basic geometric shapes is as follows:

- the majority of shapes required for a technical figure generation system can be constructed from the few primitive shapes provided,
- reducing the number of shapes supported reduces the number of menu choices, thus making selection of functions by the user quicker and less confusing, and
- by not directly supporting one area of shapes (such as for computer science) it is hoped that OZDRAW will remain a general figure generation system.

The system provides an interactive facility to edit existing figures. The available edit choices are:

- move a figure,
- remove a figure,
- move a block,
- copy a figure,
- view a figure's attributes, and
- change a figure's attributes.

OZDRAW has been designed in such a manner that it is not constrained to one particular printer, such as the QMS laser printer that was used during OZDRAW's development. This is a distinct advantage which allows printers to

be changed with little effect on the system. This generality has been achieved as follows. Firstly, attributes are handled as integers and not as descriptive names. For example, at present a medium dashed line is entered as line-style **2** and not from a menu that specifically mentions that this choice would set line-style to medium-dashed. Therefore the cost of generality is having a system that is less friendly. However, with a users-manual that provides detachable examples of the attributes this limitation can be minimised. Secondly, OZDRAW itself does not interact with the printer directly. Instead a file containing the figures is produced by OZDRAW and a separate utility programme is responsible for transforming the file from ASCII characters to figures on the page. At present this function is performed both by the OZPRINT print utility and by the FIG drawing system.

Therefore to change printers for OZDRAW entails minor modifications to OZDRAW and the development of a new print utility.

For a more detailed description of OZDRAW and it's operation refer to the OZDRAW USERS MANUAL, which appears as Appendix B. Examples of figures produced by OZDRAW, produced as part of other theses, follow.

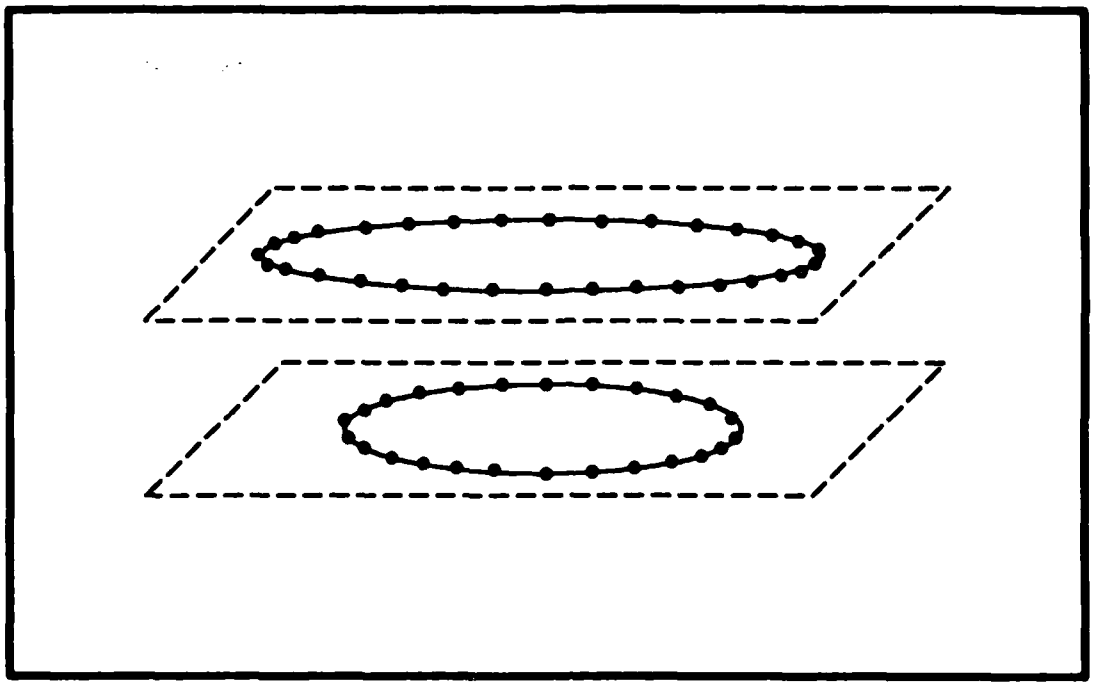
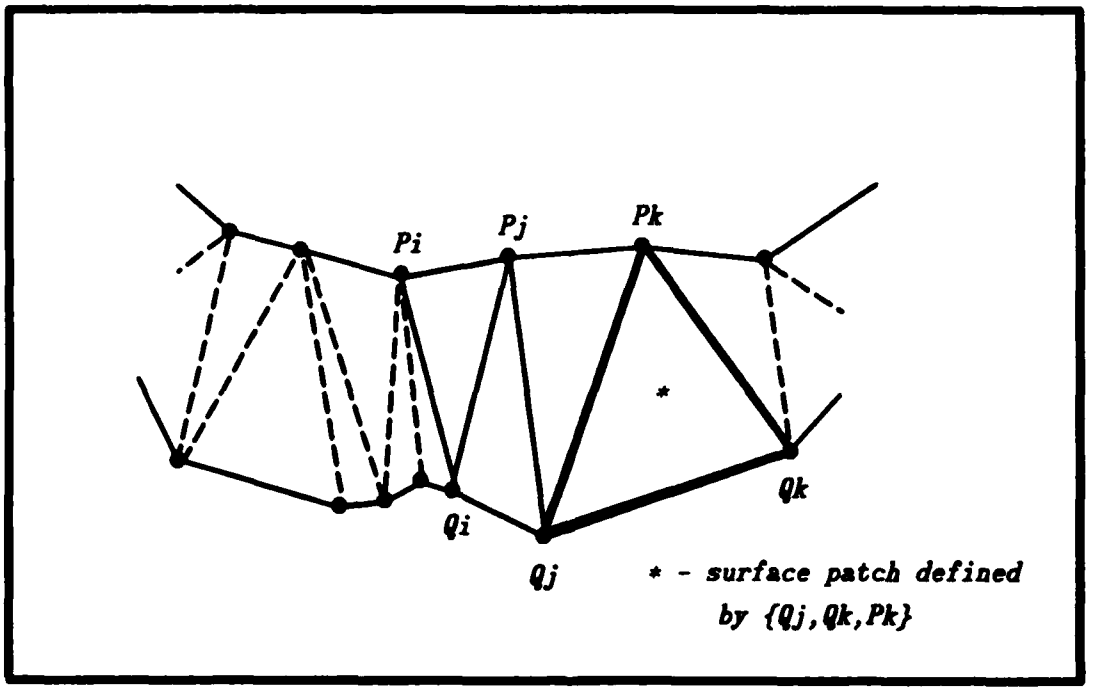


Fig 1.1 - Two contours on adjacent, parallel planes



Example 1

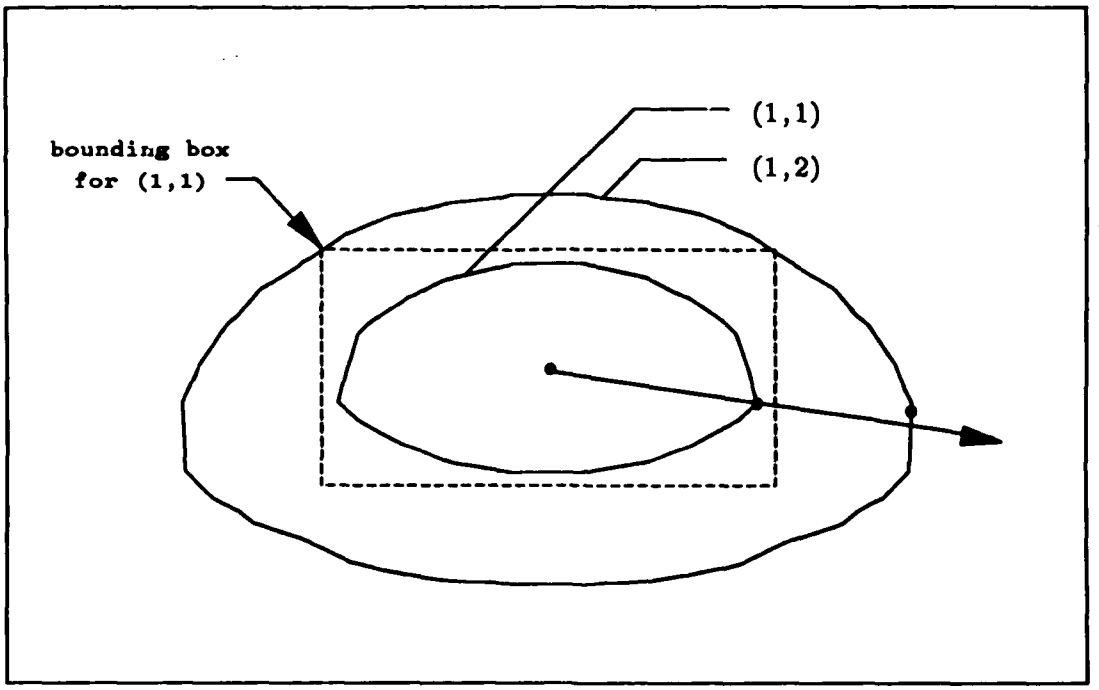
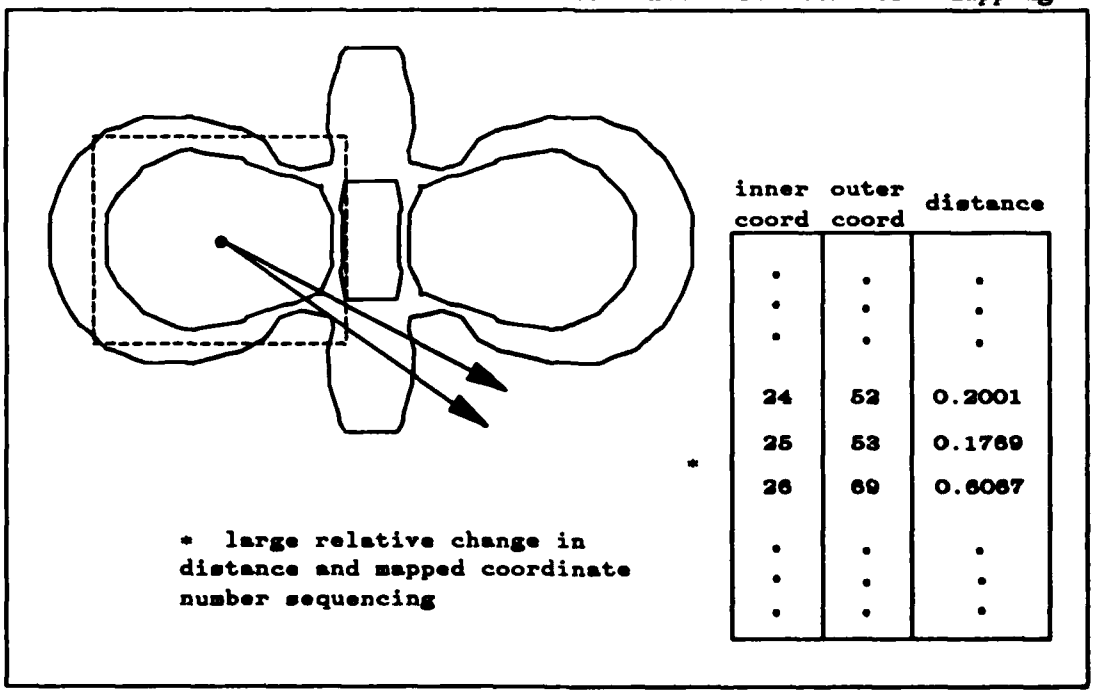
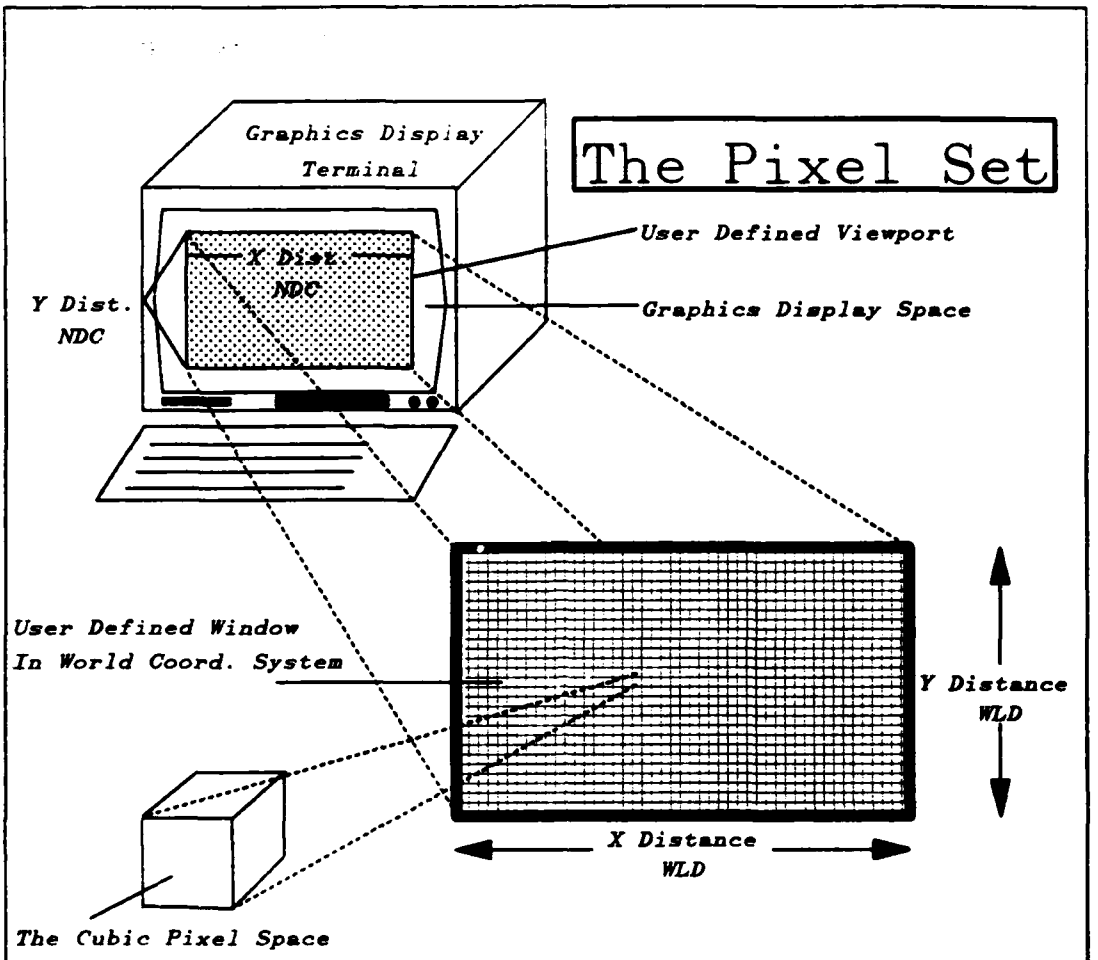


Fig. 3.10 - Vector radiating from center coordinate through the interior coordinate towards the outer contour for tentative mapping



Example 2



The Pixel Size Is Defined By

$$\text{PIXEL\_SIZE} = \frac{X_{WLD}}{X_{NDC}}$$

The Z Depth In Pixels Is Defined By

$$\text{Z-Depth}_{Pix} = \frac{\text{Z-Depth}_{WLD}}{\text{PIXEL\_SIZE}}$$

Figure 3.2. Normalizing the Pixel Space.

Example 3

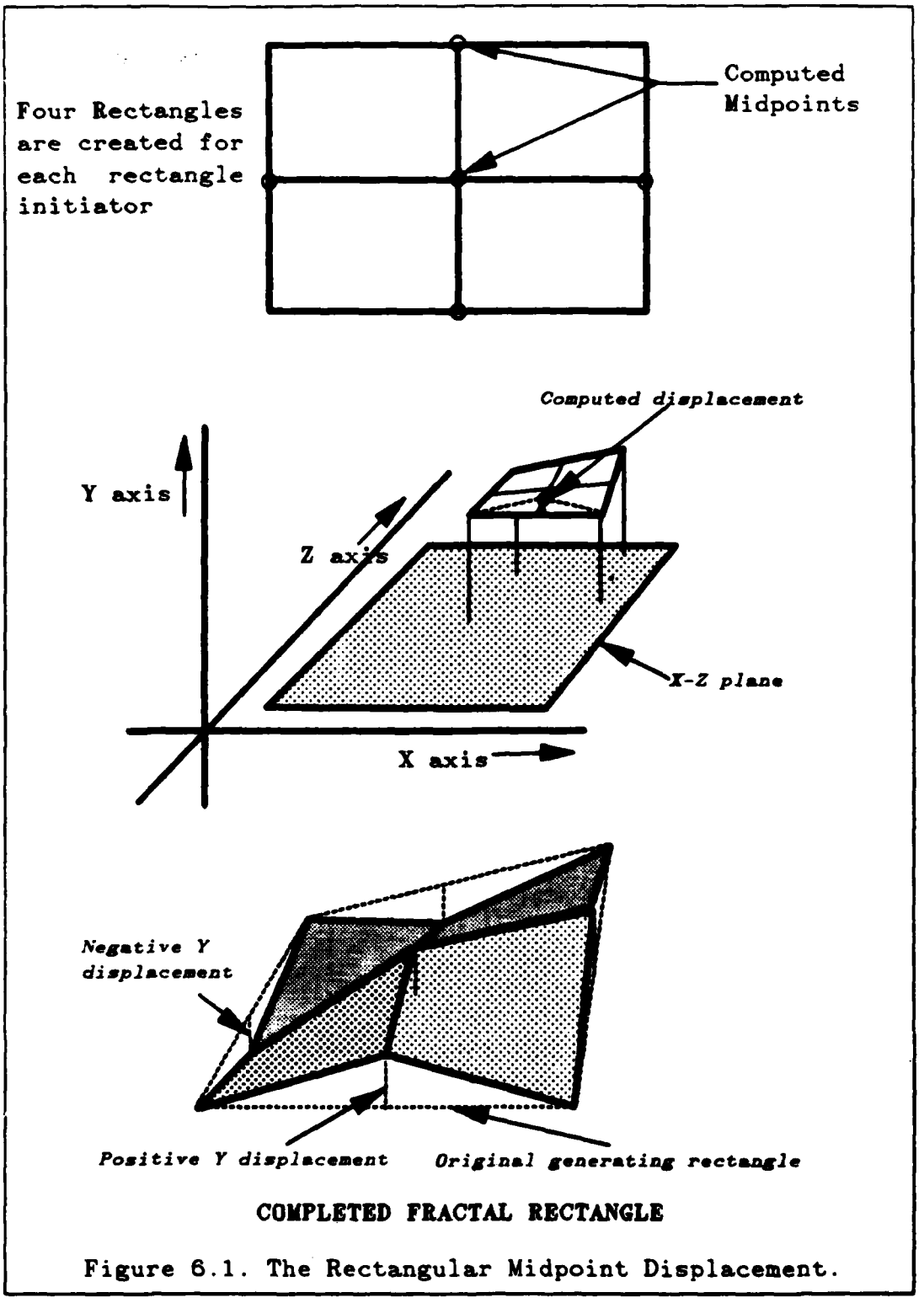


Figure 6.1. The Rectangular Midpoint Displacement.

Example 4.

VII. CONCLUSION AND RECOMMENDATIONS

OZDRAW was produced to explore the human ergonomic factors of interactive computer-graphics and to enhance the figure generation capability of the computer science department of the US Naval Postgraduate School. Much was learned in a practical way of designing an interactive system to meet the remarkably different needs and expectations of the variety of users. OZDRAW was written in the C programming language and took more than 10,000 lines of code to complete. As a pleasant side-effect the CS department now has a quick, efficient and effective method to produce high quality figures.

However, as with most projects there are additional features that would greatly enhance the capabilities of OZDRAW. The following additions to OZDRAW are recommended:

- the ability to magnify chosen areas of the page to enable the accurate drawing of small objects,
- the ability to enlarge and shrink figures,
- the ability to define an area of the page and to be able to delete whole objects or parts of objects that lie within that area,
- the ability to define objects that can be stored between drawings, that can be recalled at any time on a single command.
- the ability to rotate individual objects or blocks of objects.

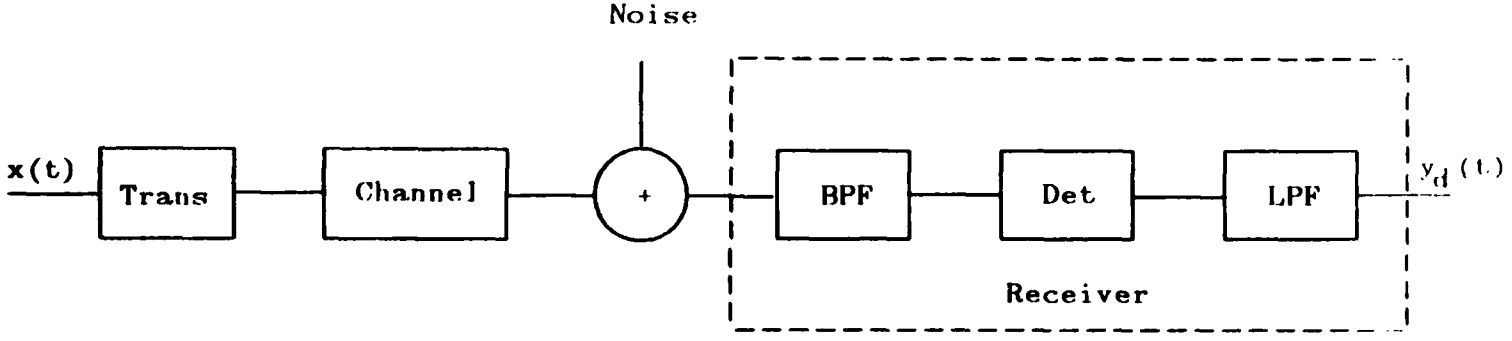
OZDRAW has succeeded in becoming a popular method for students and professors to produce high quality figures for such things as papers and theses. The impressive graphic capabilities of the IRIS series of workstations has enabled figure creation and editing to be carried out in real time, thus allowing high user productivity.

APPENDIX A - A TYPICAL DBLOCK COMMAND FILE

The following is an example of a command file produced by the figure generation system DBLOCK and the figure it produces.

```
horz
*
defn dx 5
defn left 4.5
defn axis 20
*
null title 20 10 'CW Communication System' .7
*
char .6
size 1.5 1.2
alph script '%'
box trans left+dx-1.5 axis 'Trans'
box chan trans+(dx,0) 1.9 1.2 'Channel'
circ add chan+(dx,0) 1 '+'
box bpf add+(dx,0) 'BPF'
box det bpf+(dx,0) 'Det'
box lpf det+(dx,0) 'LPF'
*
null noise add+(0.4) .75 'Noise'
labl left axis+.9 'x(t)'
labr blank r.lpf+(2.9) 'v$-*D$0*(t)'
*
box rec dash det 7.7 2.8
null label b.rec+(0.7) 'Receiver'
*
set arrow
line left axis 1.trans
```

```
line r.trans 1.chan
line r.chan 1.add
line r.add 1.bpf
line r.bpf 1.det
line r.det 1.lpf
line r.lpf $+(2,0)
line b.noise t.add
```



CW Communications System

APPENDIX B - THE OZDRAW USERS MANUAL

This appendix contain the OZDRAW USERS MANUAL. This manual describes the capabilities of the system and also provides detailed knowledge to aid the user in it's operation.

This appendix is designed to be a "stand-alone' document, as it will be used by users who will generally be disinterested in the actual content of the proceeding thesis.

THE

OZDRAW USER'S

MANUAL

by

Steven Firth

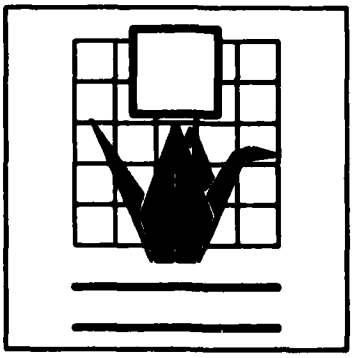


TABLE OF CONTENTS

INTRODUCTION TO THE SYSTEM

OZDRAW is an interactive figure generation system designed to operate on the IRIS 2400 workstations manufactured by Silicon Graphics Inc, of Mountain View, California. OZDRAW was written by Steven Firth in 1985 at the US Naval Postgraduate School, Monterey, California. The study was funded by the Royal Australian Navy.

The aim of OZDRAW is to provide a powerful, yet friendly, general purpose figure generation system to allow untrained users to produce high quality figures that can be used for presentations, technical papers and academic theses. OZDRAW has been designed so that the user can efficiently operate the system with little or no experience. The system uses pop-up menus to provide the user with the available instructions; menus use text rather than icons to provide an interface that is less ambiguous to the inexperienced user.

The system requirements for OZDRAW are:

(1) an IRIS 2400 workstation, ideally with three megabytes of memory and a floating-point accelerator, and

(2) the IRIS mouse

(3) a graphics printer capable of quality graphics production; a laser printer is the preferred printer.

This manual is divided into the following three sections:

(1) Section One - a very quick overview of the system,

(2) Section Two - detailed description of the system, and

(3) Section Three - a discussion of the particular printer currently in use.

SECTION ONE - A QUICK OVERVIEW.

This section is designed for the new user who wishes to know the bare minimum to operate the system. This section is not recommended for those users inexperienced with computer systems, especially computer graphics systems. For these users it is recommended that a reading of Section Two and Three would be more appropriate.

OZDRAW is envoked by the command:

ozdraw

Note, no command line arguments are accepted.

OZDRAW allows two alignments of the page, either vertically or horizontally. Choice of an alignment for a series of figures is not binding; by writing figures to a file and then back into the system the alignment can be changed at any time.

OZDRAW is almost completely menu-driven; that is all choices are by selection of menu items, not by typed commands. At various times the menu selections are augmented by key-stokes on the keyboard. At all times OZDRAW displays the functions of the mouse buttons and the active keys on the screen.

An interactive edit facility is provided by OZDRAW so mistakes during drawing can be quickly and easily rectified.

Once completed, the figures must be stored in a file for later printing. OZDRAW **does not** print the file directly. A directory listing facility is provided to enable the user to view the files contained in his current directory. This facility cannot be used to view any other directory.

To print the file produced by OZDRAW issue the command:

ozprint -alignment filename [-alignment filename]

where alignment is : v for a vertical alignment, and
h for a horizontal alignment.

SECTION TWO - A DETAILED DESCRIPTION.

The following section will give a detailed description of the operation and capabilities of OZDRAW. It is recommended that for a complete coverage of OZDRAW that Section Three also be read in addition to this section.

FIGURES SUPPORTED BY OZDRAW.

OZDRAW supports the following figures:

(1) polygons, including rectangle and squares;

(2) circles and ellipses;

(3) single and continuous lines;

(4) arcs;

(5) a seed point to fill unconvenntional objects;

(6) lines of text; and

(7) arrow heads.

For a description of the procedure to draw these figures, refer to the section "Drawing a Figure".

OZDRAW FIGURE ATTRIBUTES.

OZDRAW supports four basic attributes:

(1) linewidth,

(2) linestyle,

(3) texture for filled figures, and

(4) text fonts.

These attributes are totally dependent on the printer currently being used. For a listing of possible attributes refer to Section Three.

Initially OZDRAW has the attributes set to the following values:

(1) Linestyle - continuous line,

(2) Linewidth - one pixel width,

(3) Texture - a clear texture, and

(4) Font - 6 lines per inch, 10 characters per inch.

The IRIS workstations provide only one pre-defined font. Therefore, all but one of OZDRAW's selectable fonts cannot be displayed as they would on the printed page. To partially overcome this limitation OZDRAW does the following. When any font is selected, other than the default font (see Section Three), a red rectangle is shown around the text. This rectangle represents the area that the text will occupy on the printed page. Note, this displayed rectangle can either be larger or smaller than the displayed text.

For similar reasons OZDRAW does not realistically display all the textures that can be printed. OZDRAW will certainly display a clear texture as such, but most of the other textures will be displayed as one set texture. For a graphical representation of each texture, see the printer supplement at the end of this manual.

THE PRINTED PAGE SIZE.

OZDRAW is designed to produce figures for a standard paper size (8.5"x11"); this size cannot be changed. OZDRAW allows the user to print the page either vertically or horisontally; that is either 8.5 x 11" or 11 x 8.5" respectively.

THE IRIS MOUSE AND CURSOR.

OZDRAW uses mainly the mouse, and to a lesser extent the keyboard, for user input to the system. For instance selection of menu choices is done via the mouse.

The IRIS mouse has three buttons associated with it; these are located on the upper side of the mouse. These buttons are referred to in this manual and by OZDRAW as the Left, Middle and Right mouse buttons. Their individual locations are thus self-explanatory. Moving the mouse across the surface of the work-desk (or any appropriate surface) moves the position of the cursor on the terminal screen. The cursor can appear as a small pencil when in the drawing mode, or as a red square when the user is being asked to select an answer to a prompt. A description of menu items will follow later in this manual.

Sometimes when pressed the mouse buttons give a "double-bounce", th is it appears to the system that the user has pressed the mouse button two, or more, times. This occurrence can be annoying as it may produce results that are not expected. Therefore it is advised that the mouse buttons be pressed in a crisp, sharp manner to avoid this problem.

STARTING OZDRAW

OZDRAW is envoked by the command:

ozdraw

Note; no command-line arguments are used. For the path-name to locate OZDRAW within your system consult your local system management.

When beginning the drawing process, OZDRAW will prompt the user for the page alignment. This alignment can be either vertical or horizontal; this choice is represented graphically so no confusion should arise.

Choice of page alignment is not binding; at any time during the drawing process the user can change alignment by writing the figures to disk, changing the page alignment and then reading the figures back into the system.

SCREEN LAYOUT.

During the drawing process OZDRAW displays a portion of the intended printed page as well as system information and prompts. For more information on the later, refer to the section "System Prompts".

OZDRAW does not display the entire page; only 8.5 x 8.4" of the page is seen at any one time. When using a horizontal page alignment the entire height is seen, but not all of the width. When using the vertical page alignment vice versa occurs; all of the width is seen, but no all of the height. When in a drawing or an edit function the page can be moved around, via the Arrow keys on the keyboard.

Initially OZDRAW displays a grid overlaying the page; for a description of this grid refer to the section "The Grid Overlay" in this manual.

Superimposed on the page is a red dotted rectangle. The area within this rectangle is NOT the entire page; this line represents what generally is regarded as the correct margin settings for normal use. The choice of the size of this rectangle reflects the page layout dimensions required for a thesis page at the US Naval Postgraduate School. OZDRAW does not place any restrictions on where the user draws on the page; if required, the user can draw outside the boundaries of this rectangle, up to the border of the page itself.

SYSTEM PROMPTS.

During the drawing process OZDRAW allocates the right-hand side of the screen for system information and prompts. The inexperienced user is recommended to refer to these prompts throughout the drawing process.

The information/prompts displayed, listed in order from the top of the screen, are:

(1) File In Use - displays the file that is currently being produced/edited. This name is set when a file is read into the system; if no file has been read in then this area is blank.

(2) Cursor Position - displays the current position of the cursor, measured in inches, from the lower left-hand corner of the screen. If the cursor is not in use then 0.0, 0.0 is displayed. Note, this display is for information only and does not have any effect on the cursor positioning.

(3) Main Menu - as the name implies this is the main menu for the entire system. The functions selected from this menu will be described later in this manual.

(4) Key Functions - displays which keyboard keys are active at any one time. If a key is not listed then it is not active; pressing an inactive key will have no effect.

(5) Mouse Functions - lists the functions of the three mouse buttons. The buttons are identified by black squares (representing the button), with a letter inside it. The letter "L" represents the left mouse button, the letter "M" the middle and the letter "R" the right mouse buttons.

THE GRID OVERLAY.

OZDRAW has the facility to overlay the displayed page with a grid. This grid is there to aid the user align figures on the page: this grid is not printed on the paper copy. This grid can be altered by the user; this option is selectable from the Draw Menu.

The allowable settings of the grid are:

(1) not displayed,

(2) each grid equals one-half inch, and

(3) each grid equals one-quarter inch. (the initial setting)

THE MENU STRUCTURE.

The user inputs commands to OZDRAW via a series of pop-up menus. These menus are organised in a hierarchical structure, as detailed in Figure 1.

Selection of a menu command is done via the mouse buttons. The outside mouse buttons (left and right buttons) scroll the highlighted command up or down. This scrolling can be done with a series of individual mouse hits, or the button can be held down for continuous scrolling. Once the correct command is highlighted it can be selected with the middle mouse button. At all times the mouse button functions are displayed at the bottom right-hand corner of the screen.

DRAWING A FIGURE.

All drawing functions are selected from the Drawing Menu; the Drawing Menu is selected from the Main Menu. All drawing function differ slightly in operation but are basically similar. To begin drawing the middle mouse button is pushed; to finish the middle button is again pushed. As user the functions of the mouse buttons are always displayed.

During the drawing process the last figure of the type being drawn can be deleted my pressing the DELETE key on the keyboard. For example, while drawing circles the user decides the last circle he drew was not suitable, he can erase this circle by using the DELETE key. It is not an error to try to erase a figure that does not exist.

Also during the drawing process, the user can reproduce the last figure drawn by pressing the left mouse-button. The new figure is drawn at the current position of the cursor.

The following is a quick description of the procedure to draw the particular figures:

(1) **Rectangles** - press the middle mouse button to drop the first corner of the rectangle, move the cursor to draw the rectangle and press the middle mouse button when finished.

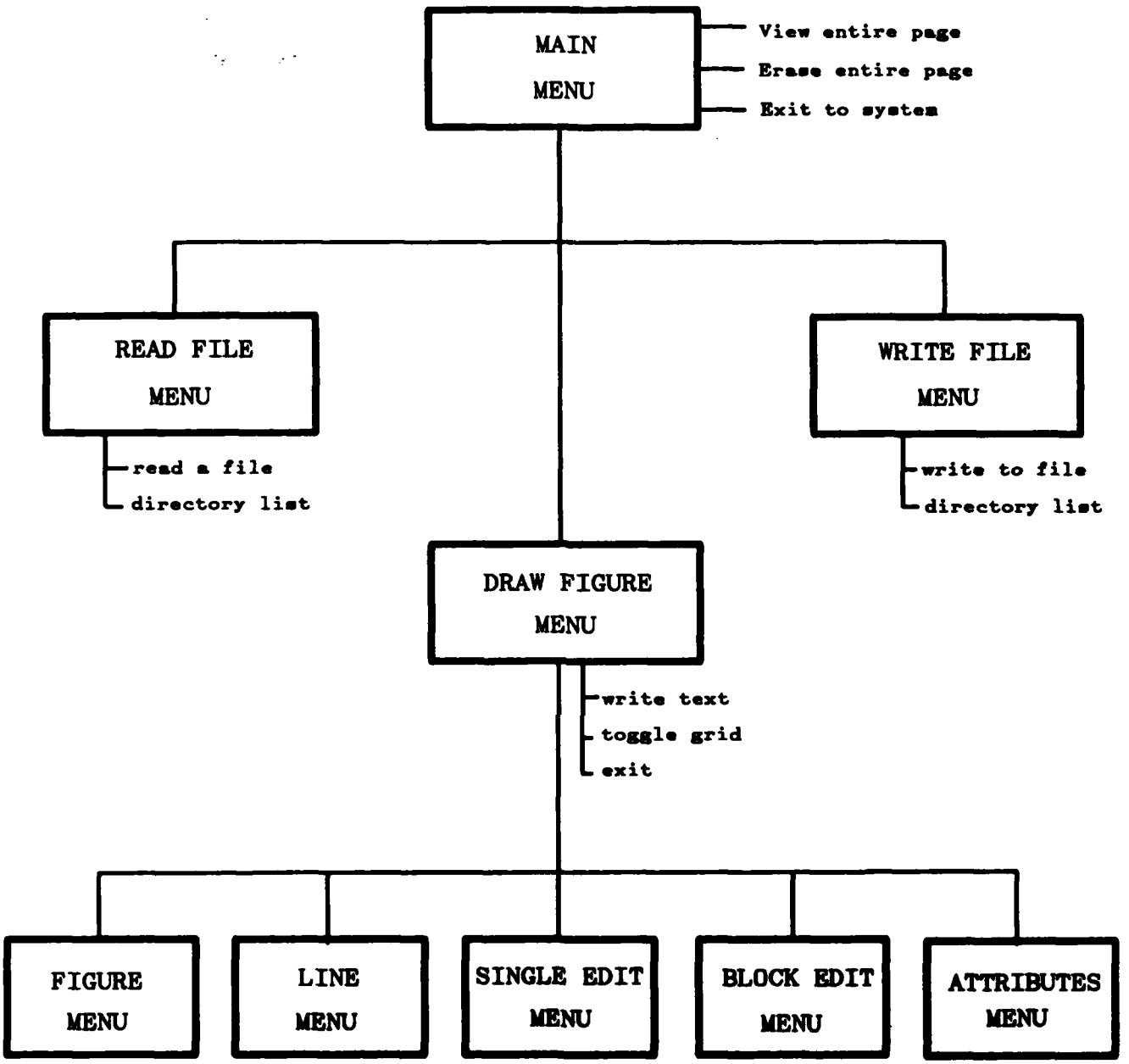


Figure 1 - OZDRAW Menu Structure and Functions.

(2) **Circles** - press the middle mouse button to choose the centre of the circle, move the cursor until the circle is drawn, then press the middle mouse-button again.

(3) **Ellipses** - press the middle mouse button to drop the first corner of a rectangle that will later contain the ellipse, move the cursor to draw the rectangle, and when finished press the middle mouse button; the ellipse will now be drawn.

(4) **Arcs** - press the middle mouse button to choose the centre of the arc, move the cursor to draw the circle, press the middle mouse button when the correct radius is selected, then press the middle mouse button to select the start of the arc, move the cursor counter-clockwise and press the middle mouse button to select the angle of the arc.

(5) **Polygons** - press the middle mouse button to drop the first point of the polygon, move the cursor and press the middle mouse button again to select subsequent points, when complete press the left mouse button.

(6) **Arrow Head** - select the position of the arrow head by pressing the middle mouse button, select the direction of the arrow by aligning the line from the cursor, press the middle mouse button when complete and the arrow head will be drawn.

(7) **Text** - choose the starting position for the text with the middle mouse button, type in the text followed by pressing the RETURN key, carry out the final positioning of the text, when complete press the middle mouse button.

(8) **Seed Point** - select the position of the seed point my pressing the middle mouse button, the seed point will have the texture that is currently set.

(9) **Single Lines** - select the first point using the middle mouse button, move the cursor to complete the line and press the middle mouse button.

(10) **Continuous Lines** - select the first point using the middle mouse button, move the cursor and the middle mouse button to drop other points, when finished press the left mouse button.

The IRIS workstation cannot fill a concave polygon. When drawing a polygon with a filled texture the user is advised that unpredictable results may occur.

THE INTERACTIVE EDIT FACILITY.

The edit functions are selected from the Edit Menu; the Edit Menu itself is selected from the Draw Menu.

There are three classes of edit facilities provided by OZDRAW:

(1) editing of a single figure,

(2) editing of a block of figures, and

(3) moving the entire page.

Selection of individual figures is done by positioning the cursor over the "control point" of required figure and pressing the middle mouse button (an explanation of control points will follow later). If an object was found OZDRAW will cause the figure to blink; if the blinking figure is correct the user confirms this by pressing the middle mouse button. If it is the incorrect figure the user rejects it by pressing either of the outside mouse buttons. If no figure was found then an error message is displayed. Once a figure has been selected then the required editing action is carried out.

Selection of more than one object is done by the user drawing a special rectangle around the required figures. If any figure has a control point inside this rectangle it will be selected. Once selected the edit action is carried out.

Moving the entire page is straightforward; the page is reduced so that the user can see the entire page, and via the arrow keys all the figures on the page are moved about.

The control points for the various figures are as follows:

(1) **Polygons and Rectangles** - any corner.

(2) **Circles and Ellipses** - the centre point.

(3) **Arcs** - either end point.

(4) **Text** - the first letter.

(5) **Lines** - any end point or internal junction.

(6) **Seed Point** - the centre point.

QUERYING ATTRIBUTES.

OZDRAW allows the user to query attributes set either of a particular figure or of the current set attributes.

The facility to view the set attributes of a particular figure is selected from the Edit Menu. The user selects the figure by placing the cursor over a control point (see the section "The Interactive Edit Facility" for a discussion of control points) and pressing the middle mouse button. The attributes of that figure are then displayed on the screen.

The facility to view the values set for the current attributes is selected from the Draw Menu. Once selected the current settings are displayed on the screen.

ERASING THE PAGE.

Erasing the entire page can be done two ways:

(1) remove individual figures, one at a time, using the interactive edit facility, or

(2) erase the page in one function; this function is selected from the Main Menu.

Note, erasing the entire page using the second option resets all attributes to their default values. For the value of the default attributes refer to the section "OZDRAW Figure Attributes."

READING AND WRITING A FILE

To print a file or save a drawing, the figures need to stored in a file. Naturally there is a facility to retrieve this drawing from a file. A directory listing facility is also provided; this facility can only list the files contained in the users current directory. Both the Read and Write operations are selected from the Main Menu. Both operations are similar in format; the user is prompted for a file name which is typed at the keyboard.

If the user wishes to read a file OZDRAW checks two conditions:

(1) OZDRAW checks if the file exists; if it does not exist an error has occurred and the user is informed.

(2) OZDRAW checks if any figures are displayed on the screen. If there are, OZDRAW asks the user if he wishes the file to overwrite the figures (that is erase the old figures) or to append the file to the displayed figures (that is the old figures remain along with the new figures).

If the user is writing to a file, OZDRAW checks if the file exists. If it does not then the file is created and the figures written to that file. If, however, the file does exist, the user is asked if he wishes to append the figures on the end of the file, or if he wishes to overwrite the file. Note, if the user chooses to overwrite the file the old contents are destroyed; be careful when overwriting a file.

PRINTING A FILE.

OZDRAW itself **does not** actually print the figures produced by the user. Instead OZDRAW produces a file, named by the user, that can be printed later by a print utility called, not surprisingly enough, **OZPRINT.** (For those interested all printer dependent functions are carried out by this utility; OZPRINT must be altered for different printers that are used with OZDRAW.) Consult local system management for the location of OZPRINT in your system.

The method to print a file produced by OZDRAW is to issue the following command:

ozprint -alignment filename [-alignment filename]

where alignment is : h for horizontal, and
v for vertical.

Note that more than one file can be printed in this manner, as long as the correct number of alignment values are placed in the appropriate places.

For example to print the file junk1.dwg, with a vertical alignment, as well as file junk2.dwg, with a horizontal alignment, the following command would be issued:

ozprint -v junk1.dwg -h junk2.dwg

FILE FORMAT.

OZDRAW stores the user produced figures in a file that uses ASCII characters. The actual file format is readily understandable by inspection of any OZDRAW file, so no further description will be given here.

Using an ASCII file format gives the following advantages:

(1) the OZDRAW file can be edited by the user using any suitable text-editor; this approach is certainly only recommended for the experienced user as errors can produce unpredictable results, and

(2) the ASCII format lends itself to other programmes producing complex figures, for use with OZDRAW, that would normally be impractical to draw with OZDRAW.

EXAMPLES OF FIGURES PRODUCED USING OZDRAW.

The next four pages are included to show to the new user what OZDRAW is capable of. These figures were produced by students (other than the author) for their academic theses.

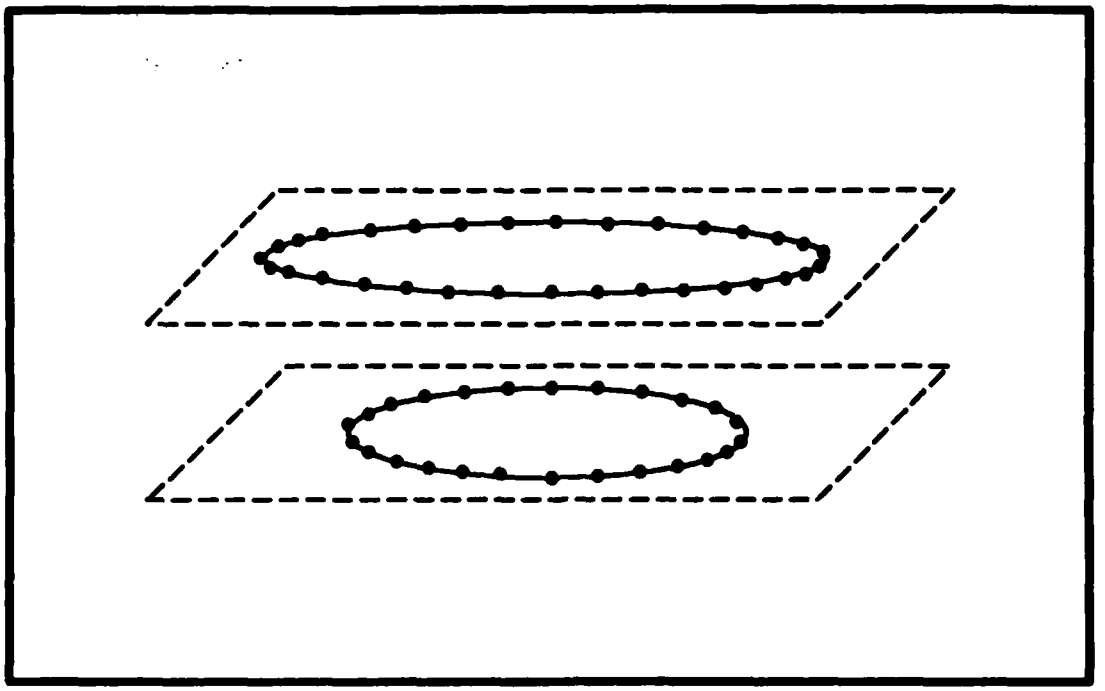
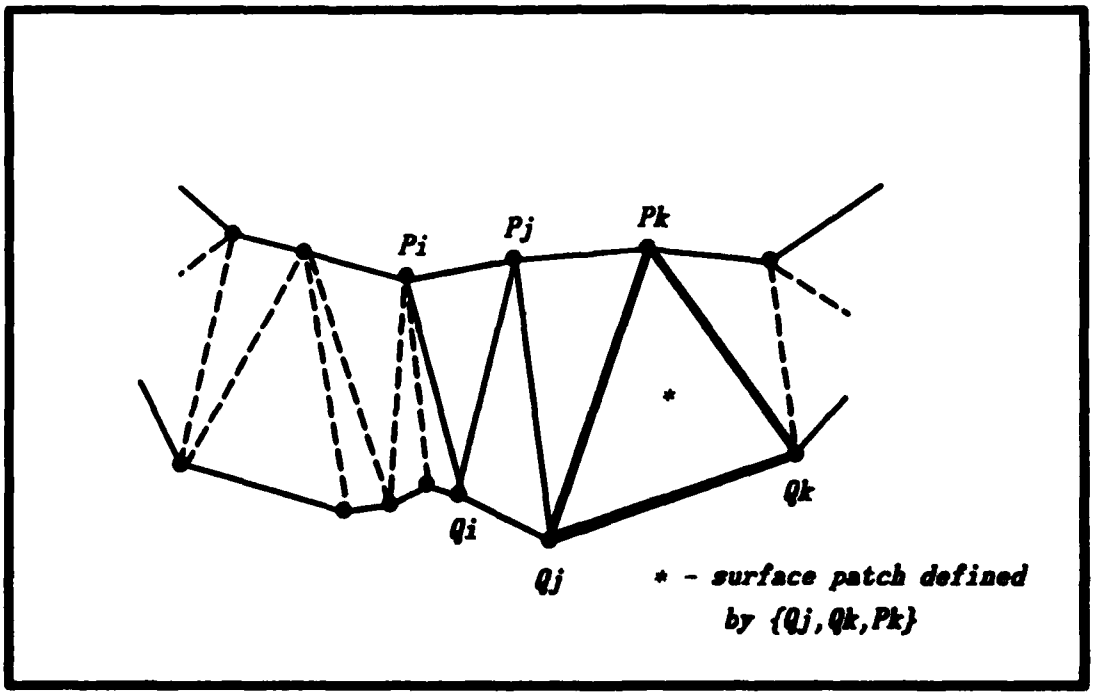


Fig 1.1 - Two contours on adjacent, parallel planes



Example 1

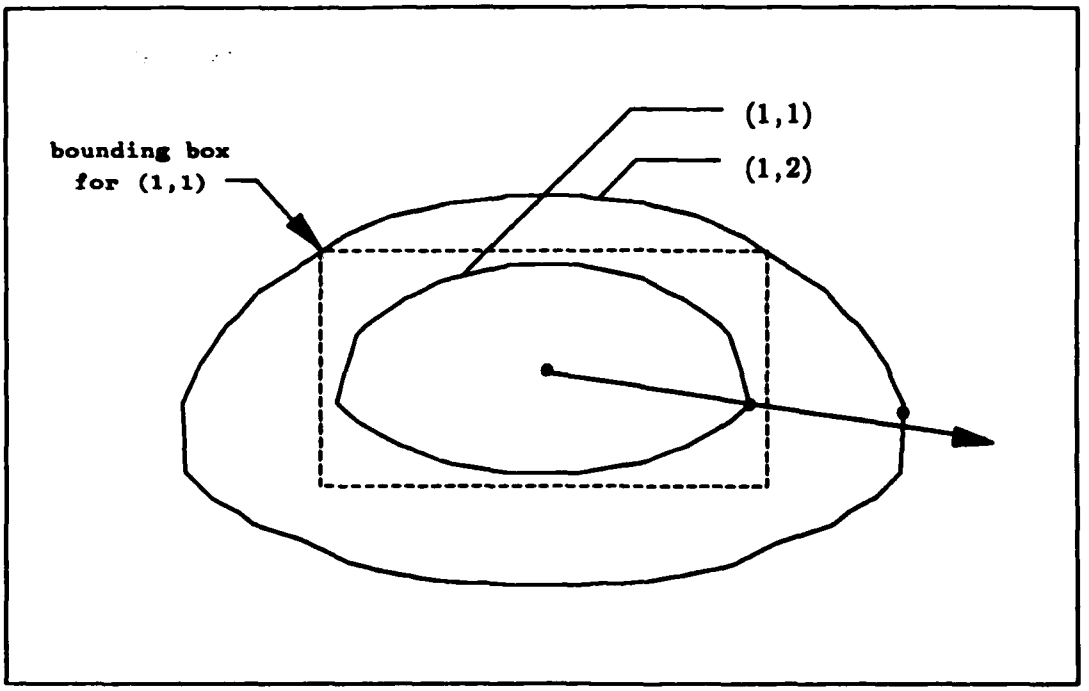
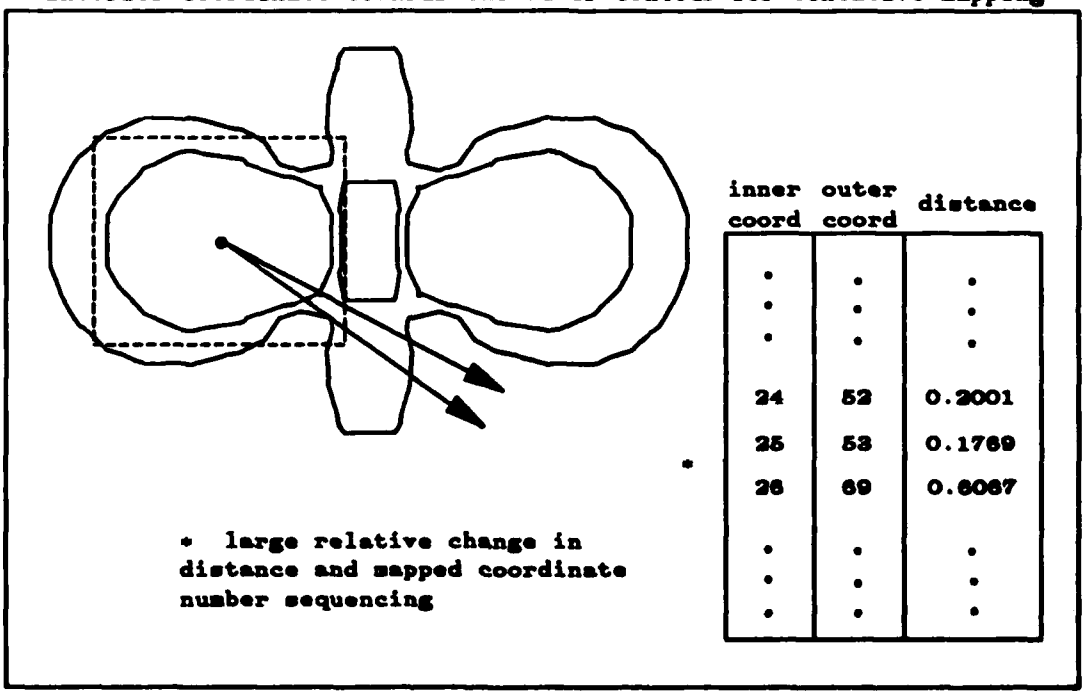


Fig. 3.10 - Vector radiating from center coordinate through the interior coordinate towards the outer contour for tentative mapping



Example 2

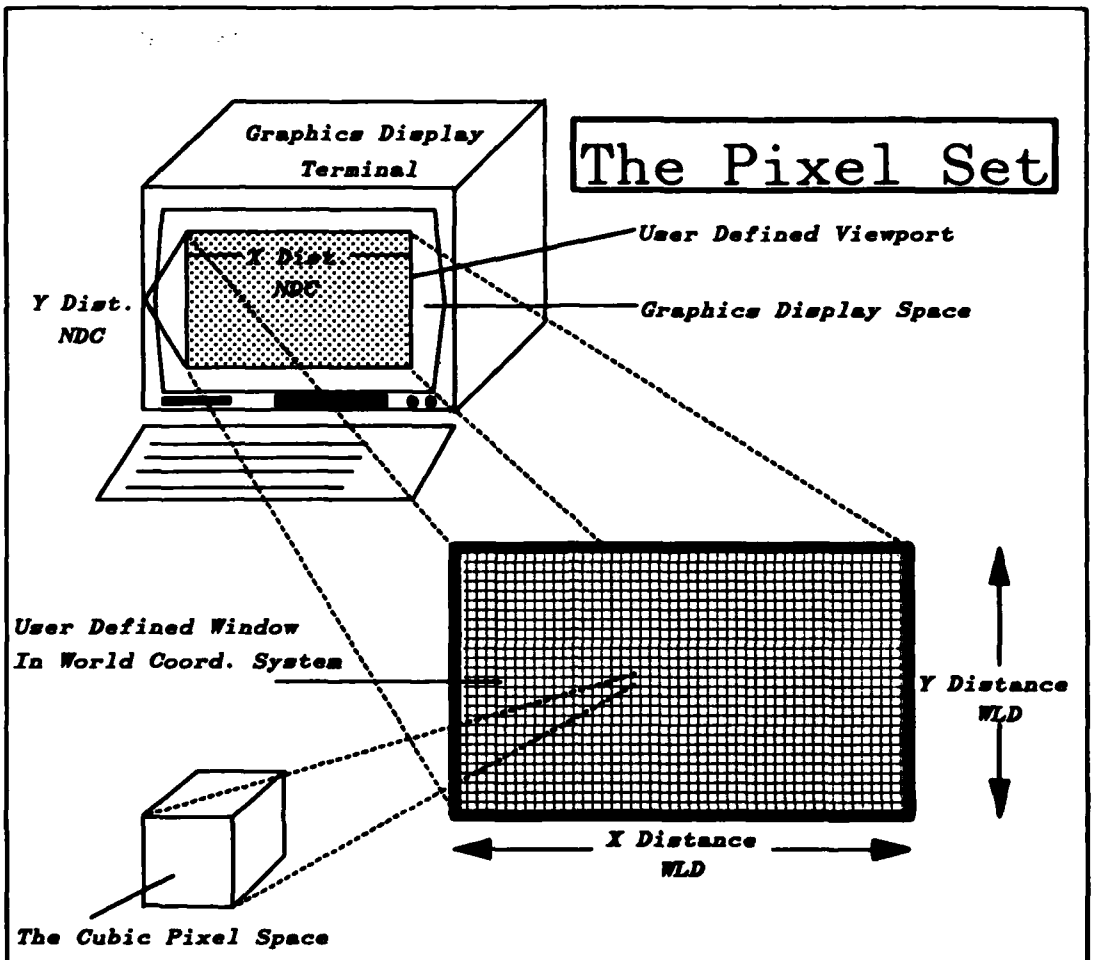


Figure 3.2. Normalizing the Pixel Space.

Example 3

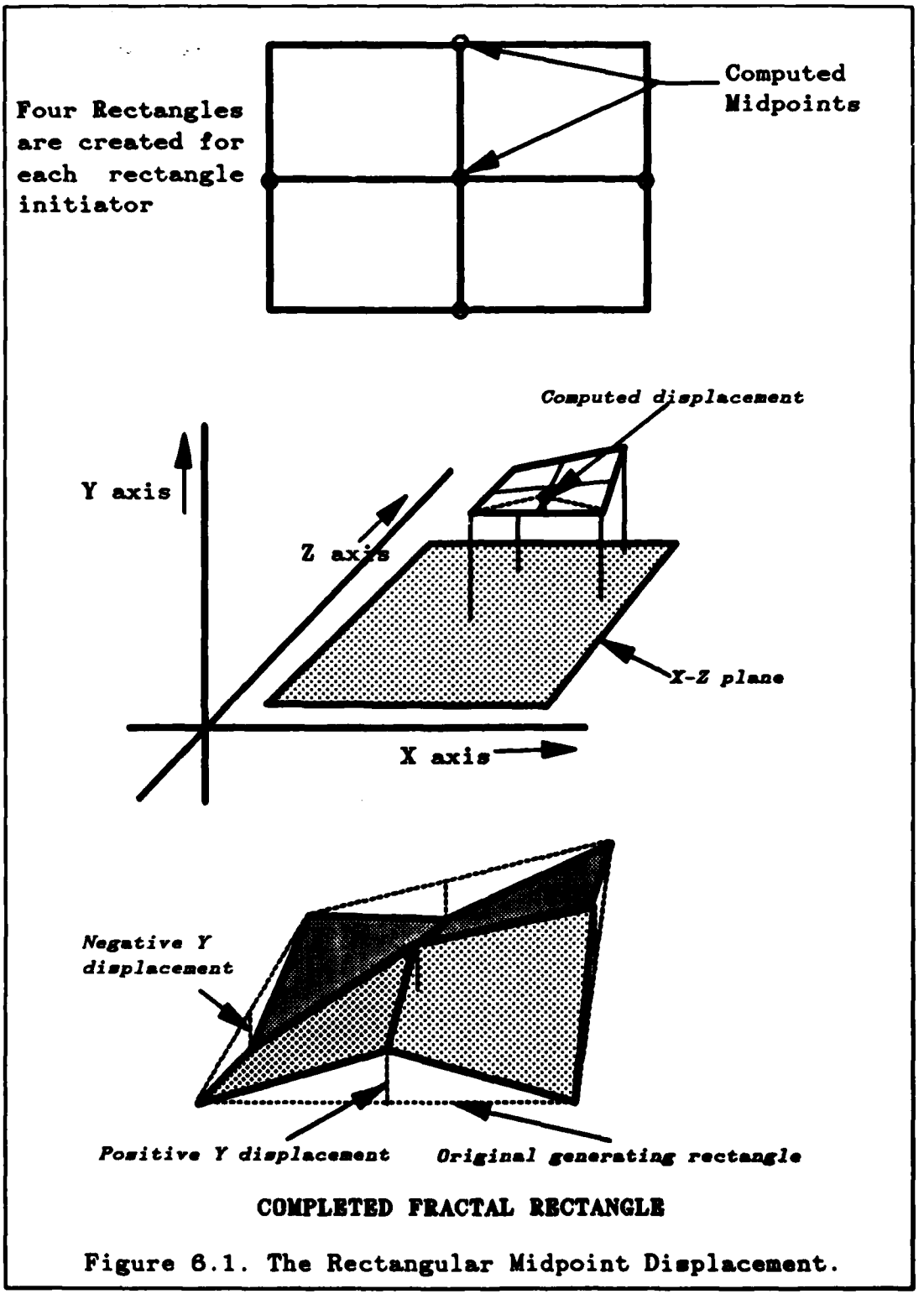


Figure 6.1. The Rectangular Midpoint Displacement.

Example 4.

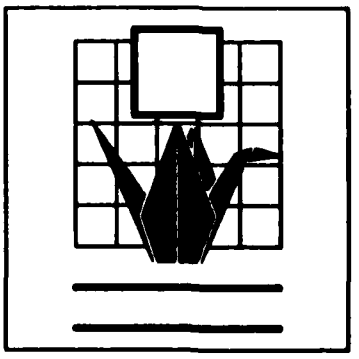
SECTION THREE - PRINTER DEPENDENT INFORMATION

The following is included as a supplement to detail the requirement and capabilities of the printer currently being used with OZDRAW. This section will be maintained by local personnel.

THE OZDRAW

QMS LASER PRINTER

SUPPLEMENT.



OZDRAW AND THE QMS LASER PRINTER.

This supplement to the OZDRAW is designed to detail the various attributes used with the QMS Laser Printer, as well as alerting the user to local peculiarities.

Attributes.

Currently OZDRAW can use the following attributes of the QMS laser printer:

(1) four linestyles,

(2) five linewidths,

(3) sixty-one fonts, and

(4) twenty-seven textures.

For a graphical display of these attributes see the end of this supplement.

The Seed Point

When dropped a seed point will fill up to either the boundary of the page, or a solid line. Use this facility with caution as an error may have strange results. For example dropping a seed point inside a rectangle with a dotted boundary will cause the entire page to be filled.

OZPRINT

The print utility OZPRINT is in reality a driver programme that uses the FIG drawing system to draw the user's figures. OZPRINT parses the parameters and then calls FIG and spawns it into the background.

A source of error is calling OZPRINT twice, or more, in rapid succession. This error is caused by FIG using a scratch file to store some intermediate data. When more than one OZPRINT is executing at one time, collisions over this scratch file may occur, thus leading to errors.

Therefore to avoid this error allow several minutes between calls to OZPRINT. This should not be too inconvenient as OZPRINT allows more than one file to be printed at a time. Refer to the OZDRAW Users manual for further discussion.

Drawing a Filled Figure.

When drawing a filled figure there are two considerations to be taken into account:

(1) OZPRINT cannot print a filled concave figure, due to the fill algorithm it uses. Unpredictable results may occur if this is done.

(2) Printing a figure that is filled with a dotted boundary will cause more than that figure to be filled. The algorithm in use fills up to the edge of the page or to a continuous line.

If a filled concave figure is required then the following procedure can be used:

(1) set the texture to clear, that is the value equal to 1,

(2) ensure the linestyle is continuous, that is the value equal to 1,

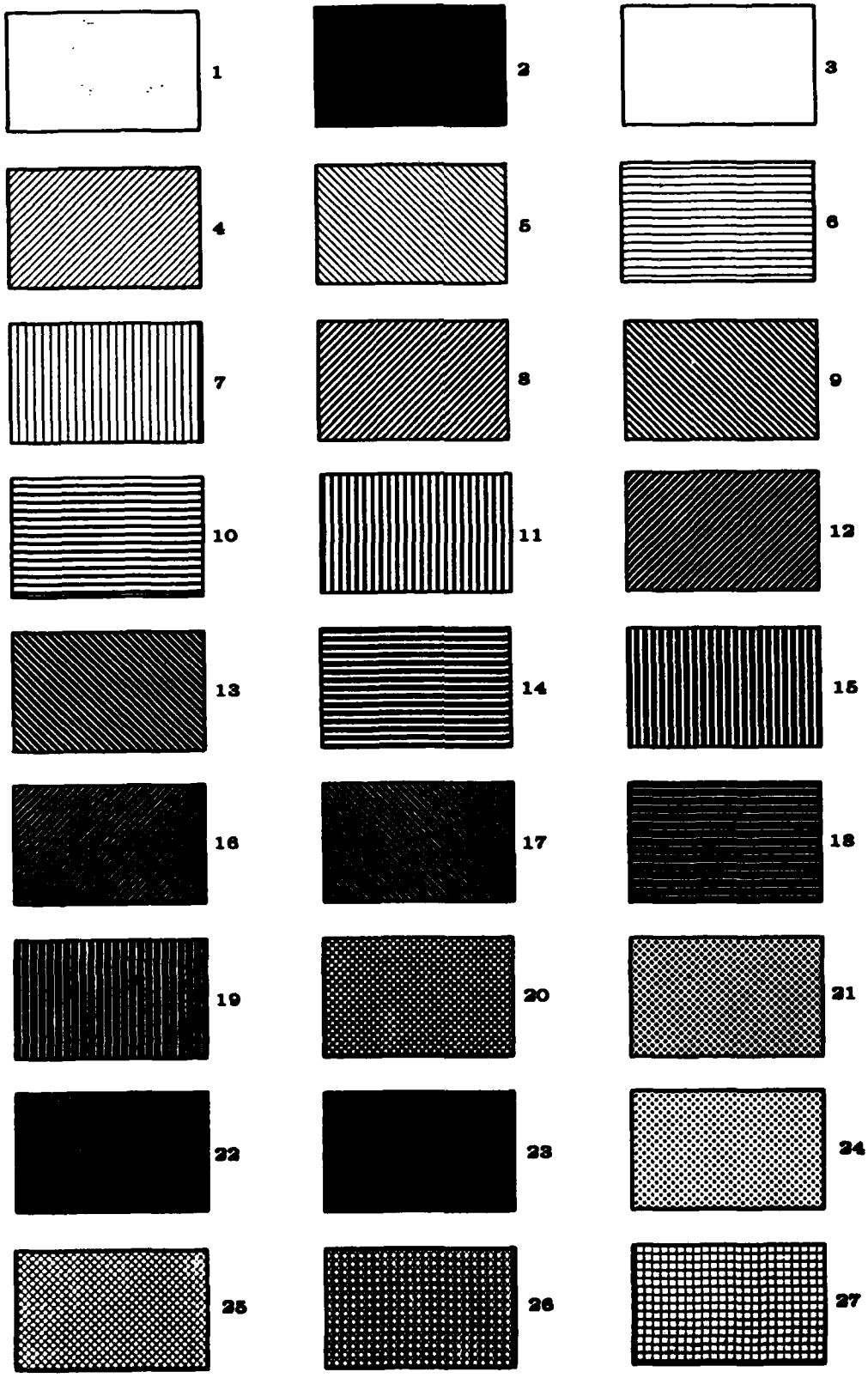
(3) draw the required concave figure,

(4) set the texture to the required fill pattern,

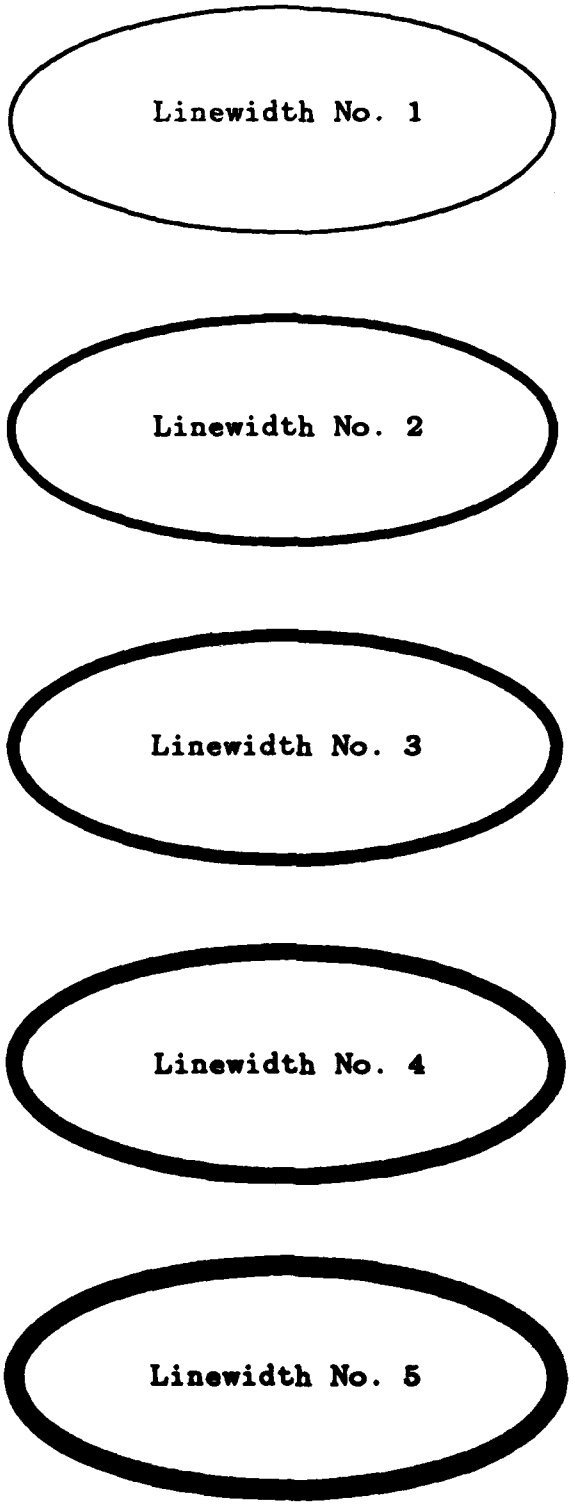
(5) drop a seed point inside the concave figure.

Clipping of Figures

The user is to be aware that OZDRAW does not undertake any clipping of figures produced during a drawing session. Therefore the figure produced may be stored in the file with portions of this figure lying outside the bounds of the page. Certainly there is no problem with this, but when the user attempts to print the figures on the QMS unpredictable results may occur. It appears that the QMS printer can handle figures that overlap the right-hand and the top edges. However, the lower and left edges are not as understanding; unpredictable therefore results may occur on these two edges if figure project off the page.



AVAILABLE TEXTURES FOR OZDRAW



OZDRAW'S AVAILABLE LINEWIDTHS

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5. Olsen,D.R., Buxton,W. and Ehrich, R., "A Context for User Interface Management", **IEEE Computer Graphics and Applications,** pp. 33-41, December 1984.

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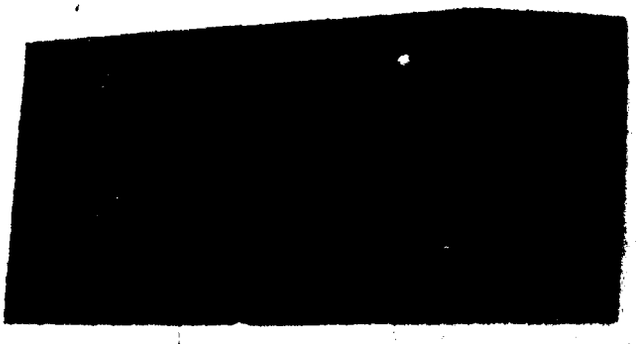

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